Center for Brain-Inspired Computing

JUMP

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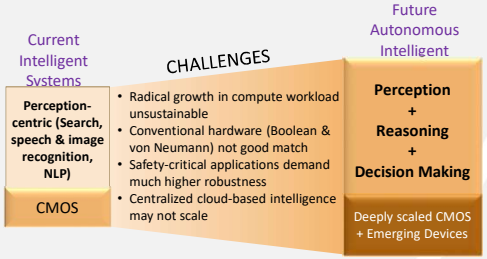
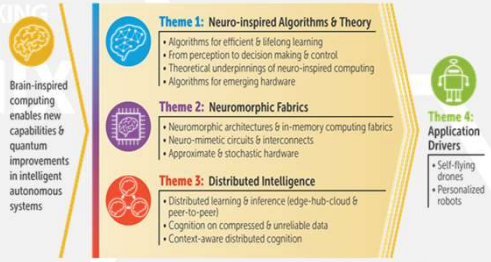
Motivation and Challenges

- Current applications of AI / machine learning are only the tip of the iceberg
  - Few large "killer apps"
- Tremendous potential for economic and societal impact if AI can be applied to a much broader range of applications



C-BRIC Vision

- Enable next generation of intelligent autonomous systems
  - Narrow the orders-of-magnitude computing efficiency gap between current computing systems and the brain
  - Drive improvements in the robustness of cognitive computing systems
  - Explore distributed intelligence across edge/hub/cloud and peer-to-peer networks
  - Demonstrate the impact of these advances in end-to-end systems such as autonomous drones and personal robotics



Theme 1: Neuro-inspired Algorithms and Theory

State-of-the-Art: Deep Neural Nets

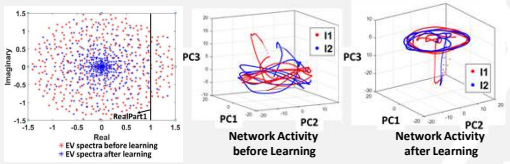
- Largely supervised learning
- Static (one-time) learning
- Training requires global updates (Backpropagation / SGD)
- Perception (speech, images, text)
- Unknown generalization behavior
- Manually designed network topologies

C-BRIC Theme 1

Future Neuro-Inspired Algorithms

- Computationally efficient algorithms
- Theory of neural computing from DNN to emerging models
- Learning with less data
- Incremental and lifelong learning
- Algorithms that leverage stochastic and approximate computation
- Learning and inference on emerging computing fabrics

Theoretical Understanding of Learning

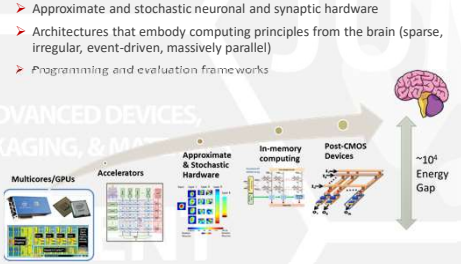


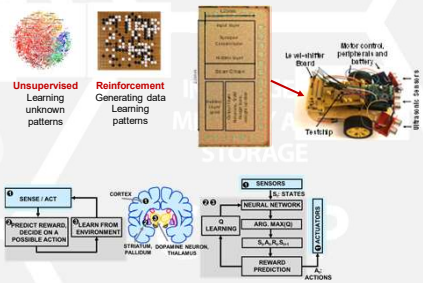
- Shrinking of the EigenValue spectral circle represents the stabilizing effect of the learning mechanism
- Understanding network behavior from Random Matrix theory and Principal Component Analysis
- Quantification of stabilizing hyperparameters from network activity

Theme 2: Neuromorphic Fabrics

- CMOS and Post-CMOS neuro-mimetic devices and interconnects
- Compute-near-memory / Compute-in-memory
- Approximate and stochastic neuronal and synaptic hardware
- Architectures that embody computing principles from the brain (sparse, irregular, event-driven, massively parallel)
- Programming and evaluation frameworks

Hardware Demonstration of Autonomous Decision Making via Reinforcement Learning





Theme 3: Distributed Intelligence

State-of-the-Art: Cloud-enabled Intelligence

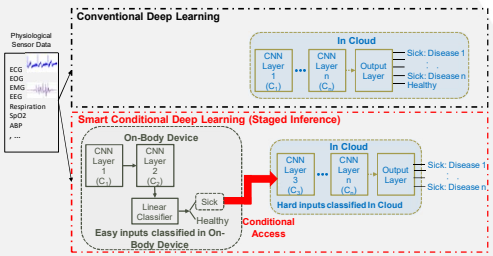
- Centralized training in cloud
- Inference entirely in cloud or entirely on edge device
- Algorithms agnostic to distributed context require high communication

C-BRIC Theme 3

Future Distributed Intelligence

- Partitioned learning and inference
  - Algorithms for hierarchical (edge/hub/cloud) and peer-to-peer networks
- Cognition on compressed and unreliable data
  - Event-driven sensors, data fusion, learning from incomplete/ unsynchronized/noisy data
- In-sensor analytics
  - Low-complexity algorithms and hardware to enable in-sensor computing

Distributed Conditional Learning/Inference



Application Drivers

- Autonomous drones and drone swarms
- Personal robotic assistants
- Technologies from Themes 1-3 enable new capabilities with real-time, autonomous operation

C-BRIC Universities

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